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Cast Jewelry in a Selection of Alloyed Metals

Mary Jo Baretich

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CAST JEWELRY IN A SELECTION OF ALLOYED METALS

A Thesis

Presented to

The Graduate Faculty

Central Washington State College

In Partial Fulfillment

Of the Requirements for the Degree

Master of Arts

by

Mary Jo Baretich

June 1966

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

The casting of metals and alloys is an ancient process handed down through the ages, improved upon by many different peoples, and used to suit varied purposes. The casting processes used in this study have as their main purpose the creation of jewelry pieces. The exploration is limited to a selected number of alloyed metals to be used in a variety of casting methods, which, in turn are dictated by the alloys.

Throughout history man has created objects to adorn and decorate himself. Some had religious motivations, others had symbolic meanings, and still others were purely decorative ornamentation. The designs created for this study have as their basic inspirations nature. The original ideas in each case, have been changed in accordance with the casting processes and alloys used and the shape of the stones used. These pieces of jewelry function as aesthetic needs.

I. THE PROBLEM

Statement of the problem. It was the purpose of this study (1) to apply metals which are adaptive to the casting of jewelry pieces; (2) to use a variety of methods in casting these pieces, the choices of which are governed by the alloy or alloys employed, and the materials used; and (3) to modify the designs in accordance with the alloy employed, and the methods and materials used.

The alloys used in this study were limited in their selection by their ease of casting, adaptiveness to the particular method used, the

designs employed, and relative inexpensiveness for use in ones personal work. The relative inexpensiveness and adaptability of these alloys to casting jewelry helps in the further development of ones general creative expression and technical ability by enabling more work to be accomplished.

Importance of the study. A purpose of this study is to arrive at a selection of alloys which are both relatively inexpensive and yet practical for the casting of jewelry. Therefore, emphasis had been placed on certain justifications concerning the validity in the use of these specific alloys.

The justifications referable to the selection of alloys in this study are (1) to enrich creative expression and technical ability concerning jewelry casting, (2) to develop a personal awareness of the possibilities for individual exploration through the use of the specific alloys, and (3) to demonstrate through this study the aesthetic qualities and values and personal beauty of each of the selected alloys.

Limitation of problem. The problem was limited to the following alloys: Britannia metal, tin bronze, aluminum bronze, sterling silver, and silicon bronze. The methods were in turn limited and dictated by the alloys utilized. Two different methods of casting were used for each of the alloys to be employed, with the exception of silicon bronze. Silicon bronze has an extremely high melting point and rapid cooling and solidification characteristics. This alloy can be cast only in the centrifugal method because of the limitations created by our laboratory.

The metals for only one of the two pieces included from each alloy were experimentally alloyed. A commercially made alloy was utilized

for the second piece, with the exception again of silicon bronze.

Duronze II, melting point 1830 degrees F, was used for each of the two jewelry pieces created in silicon bronze.

The designs for the jewelry pieces have as their inspiration, nature, but in each instance of casting, these designs had been modified in accordance with the alloys used, the methods and materials used, and the final aesthetic expression desired.

A selection of ten jewelry pieces represent the thesis.

II. DEFINITIONS OF TERMS USED

Alloy. An alloy is the combination (melting) of one metal with one or more different metals or chemical substances to form a new, stable composition.

Selection of alloys. The following alloys are the selection to be dealt with in this study: silicon bronze (silicon and copper); and sterling silver (silver and copper); aluminum bronze (aluminum and copper); tin bronze (tine and copper); Britannia metal (antimony, tin, and copper). These alloys are of the copper-base family, copper being one of the relatively less expensive of the metals employed.

Chemical symbols are used to name the metals and their formulas in this study, such as silver, Ag, aluminum, Al, copper, Cu, antimony, Sb, and tin, Sn.

Cast jewelry. Jewelry made by pouring molten metal into a cavity, the form of which is previously made into the design and form of the jewelry piece either by the lost-wax method or by the carved-out processes.

Lost wax process. The form of the jewelry piece is created in

wax, is incased in investment, the wax is burned out in a kiln, and a cavity is left where the molten metal is poured to take the place of the wax.

Carved-out process. A substance, such as cuttlebone, stone, clay, or investment is used as a base into which a design is carved. This can be in a two or three part mold. A channel is carved at one end through which molten metal is poured after the mold pieces are secured together.

CHAPTER II

REVIEW OF THE LITERATURE

Much has been written in regard to jewelry casting processes, jewelry designing, and the use of gold and silver as jewelry metals, but only a brief summary of the work done in these areas, closely related to this study, will here be given. A major emphasis, however, will be placed upon the metals and their alloys employed in this study. These alloys serve as important avenues in the jewelry casting field.

I. THE METALS

In order to acquaint the reader with the metals under discussion in this study, background information concerning the metals, their histories, properties, alloys, and uses seems a necessity at this point.

The discovery of metals and the way of working them remain among the greatest achievements of the human race. Metals are rarely used in their natural state. Man has found ways of combining them, alloying, to produce new characteristics for special needs, such as color, durability, change in melting temperatures, and chemical patination. Gold, silver, and copper, in that order and in the pure state, rank as being the most malleable and ductile of all metals.

The alloys used in this study are of the copper-base family, and the first metal to be discussed is copper.

Copper

Since copper is the basic metal employed in all of the alloys used in this study, it seems only proper to take notice of the history

and the properties of copper at this point.

History. Copper is one of the first metals to be used, dating from prehistoric times. Records show that the metal in use dates from 8000 B.C. and as early as 4500 B.C. by the Egyptians, Cretans, Bablonians, and the earlier Assyrians, besides our own North and South American early cultures, beginning about 4000 B.C. in the Great Lakes region.

According to Camm the chemical symbol Cu is taken from the Latin word, "cuprus" contraction of "Cuprium aes" the metal having been found on the island of Cyprus by the Romans. It was found and is still found in the following ores, besides in the natural pure metallic state of copper pyrites, ruby ore, and malachite. Camm added that in achemical terms the metal was symbolized by the planet Venus. (3:54)

Properties. Copper is a red-brown metal. It had been found in this study that when the metal is in the molten state it becomes a dark green, and the vapor given off is also green.

In his essay Campbell reports that copper is extremely tough and can be hammered out into a thin leaf. It can be gorged at red heat (salmon red), 1000 degrees F., is very malleable, and has a melting point of 1981 degrees F. When the metal is heated to near its melting point copper becomes so brittle that it can be powdered. (4:5)

Owing to the fact that next to silver, copper is the most electrically conductive of all metals, it is used enormously in the world's electrical industries. Copper for electrical purposes must be almost pure since small traces of impurities seriously interfere with its conductivity. Campbell cites in his essay that commercial copper is practically pure copper: 99.8% copper and .2% arsenic, which is added to harden it. (4:5)

As a casting metal, copper is used when as an ingredient in brass, bronze, and many other non-ferrous alloys. It cannot be cast well in its pure state. As a pure metal, copper will expand in the molten state and shrink upon solidification. This can be quite impractical in casting. Addition of other metals, such as tin, aluminum, and antimony cuts down this shrinkage in casting.

Copper tarnishes, or oxidizes quickly. It must be lacquered, waxed, or some other coating applied to protect its finish. This oxidation and sulfurization may be controlled by the addition of other metals to form alloys resistant to this oxidation.

Tin

Tin is the major metal used in the alloying of Britannia metal, or pewter. The other metals involved in this alloy are antimony and copper. Tin is also a minor ingredient in the alloying of tin bronze which is a combination of tin and copper.

History. It is hard to state exactly where tin was first discovered, since so many cultures throughout the world made use of the metal in the alloying of their tin bronzes and pewters in sculptures, utensils, jewelry, and weapons. Shortly before 2000 B.C. some northern people, probably in Bohemia, made a discovery that the addition of tin to copper produced an alloy much harder and stronger than copper used for weapons up to that point. (14:585) In Cornwall of the British Isles tin was found in the pre-Roman days. Camm points out that these islands were known as the "Cassiterides," or Tin Islands (The Greek word for tin is cassiteros). (3:169) Tin was known in Mesopotamia during the 5th Millennium B.C. the Persian world in the 7th Century B.C., and was passed into the 7th Century A.D. to the Moslem world. (14:585) Tin, in these countries and centuries was

combined with copper to form the tin bronze, similar to that used in the northern countries in later periods.

Properties. The chemical symbol of tin is Sn. The symbol is taken from the Latin word, "stannum" as suggested by Camm. The melting point is 450 degrees F. The metal occurs chiefly in the mineral, tin-stone or cassiterite, and it is often associated with tungsten, arsenic, and copper. (3:169)

Tin is a white, lustrous metal, having a faint blue tinge. It has been found in this study that **tin** does not easily tarnish on exposure to air. This quality is an important aspect in choosing tin as an alloying metal.

Camm further states in his discussion of tin that the metal is harder than lead but softer than zinc. It is very malleable and it can be beaten into foil...tin foil. It is also very ductile. At a temperature near its melting point, tin becomes so brittle that it can be ground into a fine powder. If a thin bar of tin is bent, it emits a cracking noise, known as the "tin cry." When cooled to a low temperature, tin crumbles into a powder ..."grey tin," a fact which Camm calls a "disease" of tin. (3:169)

An interesting point which Camm makes concerning tin is the evidence that tin can be obtained in crystalline form by melting a quantity of the metal and pouring out the still liquid portion after the mass has been allowed partially to solidify. Surface crystallization, according to Camm's recording, can be formed on tin by wiping a quantity of the warm, dilute aqua regia (mixture of nitric acid and hydrochloric acids) over a piece of tin. (3:170)

Tin is highly important metal. It is used in tinning iron, and

also in the preparation of numerous alloys, such as tin bronze, pewter, and solder.

Antimony

In this study antimony plays an important part as one of the metals in the alloy, Britannia metal, a high grade of pewter. Antimony gives Britannia metal an extra hardness and finer casting qualities than pewter not containing antimony.

History. Antimony was known in medieval times. Its preparation was described by Basil Valentine, a Benedictine monk, in 1413. Camm pointed this out. The meaning of the name, "antimony," is not known but it has been supposed to be derived from the Greek words, anti, meaning against, and nomos, meaning the law. (3:22)

Properties. The chemical symbol for antimony is Sb. The melting point is 1167 degrees F. The chief ores from which the metal is obtained are stibnite, antimony bloom, and antimony blend. It also occurs in free metallic state. (3:22)

Camm characterizes antimony as a silvery-white metal having a pronounced crystalline structure. It is very brittle and easily powdered. Antimony is a poor electrical conductor. It does not readily tarnish in dry air, but becomes covered with a film of oxide in moist air. (3:22)

When molten antimony solidifies it expands very slightly, and therefore the metal is useful in alloys such as type-metal, from which fine and sharp castings are to be made. In the instance of this study, this property aids in the reproduction of the fine markings of the cuttlebone when pewter, Britannia metal, is used as a casting alloy.

Chemical science has shown that Sb can exist in several forms, such as yellow and black Sb. The metal is attacked by most mineral acids and is chemically closely related to arsenic on the one hand and bismuth on the other. These facts have been cited by Camm in his report on antimony. (3:22)

Pewter

Pewter is an alloy with an interesting background through-out many countries and many centuries. Because of its many desirable properties, Britannia metal, a high grade of pewter has been chosen as one of the selected alloys for this study.

History. The use of pewter goes back to the time of the Romans. In those countries which had a scarcity of wood or pottery, pewter was used extensively. The forms pewter took were such household items as spoons, plates, salt cellars, and trays.

Varnum, in his book on pewter recounts the history behind the metal. According to him in the Middle Ages itinerant pewterers were accustomed to going from town to town, repairing or recasting damaged wares. A poor grade of pewter, highly lead, was used often by these workmen and was called "black pewter." The metal content of this was 80% tin and 20% lead. (15:11)

In 1348, relates Varnum, during the reign of Edward III in England, the stationary or permanently located pewterers established a well-organized guild or association. The Pewterer's Guild of England was in full control of the material and the quality of the products. (15:12)

Pewter has played an important part in the development of civilization, both as a medium for artistic expression and as a material from which domestic utensils were fashioned. The bronze used by the ancients was composed

of a large percentage of copper and a smaller proportion of tin. Now the complement of this alloy, that is, a large proportion of tin with a small amount of copper gives an excellent grade of pewter.

The discovery of pewter, whether accidental or experimental cause, has not been determined.

In his account of the history of pewter, Osburn points out that besides the English and the Romans, the Orientals used pewter. It is known that the use of pewter had its inception at a relatively early date, a fact evidenced by the pieces of Chinese and Japanese ware that have survived for many centuries.

The contributions of ancient Orientals to the pewter heritage must inevitably proceed any attempt to trace its early history. It was used very skillfully by these peoples at least 2000 years ago. The fact that the alloy which was used by the Japanese and Chinese contained considerable percentage of lead made it easy to work but rendered it of little use for table or domestic use. Hence, much of their pewter ware is found in the temples where it is used for religious purposes, or in the homes for decoration or personal adornment. (13:15)

Oriental workmen used engraving on their pieces for further surface decoration and inlaying of gold, copper, brass, jade, and ivory.

Properties. Pewter is an alloy of copper, antimony, and tin. Varnum gives the percentages of these metals in the alloy of Britannia metal as being Cu 1.5%, Sb 7.5%, and Sn 91%. The melting point of this particular form of pewter is 527 degrees F. (15:15)

Britannia metal, which does not contain any lead, can be regarded as an excellent grade of pewter and can be used with complete safety for foods

of acid content.

Britannia metal is of comparatively recent development, 1770, and was not associated with the fine traditions of pewter. The metal content of Britannia metal, although, is similar to the alloys of some of the early pewters.

The color of the metal resembles silver. The slight patina, which forms on its surface in time, may be removed readily, although in old pewter, it is regarded as a distinct artistic attribute of value, according to Varnum. (15:17) To speed up the process of creating a patina, dipping it into a "pickling" solution will cause oxidation to form on the surface.

Britannia metal has a lustrous beauty and color of its own which is desirable in the creation of jewelry. Tin, the chief member of the alloy has important qualities of whiteness and freedom from natural oxidation which lend to Britannia metal a softness and delicacy of treatment, overlooked, mainly because of its industrial uses and of its associations with kitchen utensils.

Tin bronze

The first bronze to be used was tin bronze, whether by accident or by experimentation, but in either case, the knowledge of this alloy made its entrance into the world at a rather early date. The use of tin bronze was an important advance in the fostering of civilizations through-out the centuries. Its interesting properties have marked tin bronze as desirable by many cultures.

History. Copper had been the metal used by the ancient Egyptians, Cretans, Bablonians, and the earlier Assyrians. But shortly before 2000 B.C. some northern people, probably in Bohemia, made a discovery that the

addition of tin made an alloy that not only could be melted more easily than copper but also made the resulting metal much harder and stronger. Thus began the Bronze Age which lasted until about 1000 B.C. (14:583)

Throughout the world, bronze has been worked by artist and artisan ever since the 5th millennium B.C., when mankind was emerging from barbarism. The knowledge of the casting of this metal is a mark of civilization. (14:585)

Bronze had been produced in Mesopotamia during the middle of the 5th millennium B.C. It was during this period that the first "cire Perdue" or lost wax casting were done. The Persians conquered the Assyrian Empire in the 7th Century B.C. and continued this ancient tradition of bronze working. It then passed into the 7th Century A.D. to the Moslem world. The Moslems despised images so their work was mainly utilitarian. (14: 583)

Bronze appeared in Egypt during the 1st dynasty (3200-2980 B.C.). Copper was more scarce in Egypt than in Mesopotamia. (14:586)

In China, during the Shang dynasty (1523-1027 B.C.) the bronzes were cast in the cire-perdue method. There may have been even an earlier beginning for bronze in China. This grand tradition of bronze casting passed from the Shangs, with a gradual change of style, to the Chou dynasty (1027-256 B.C.), and ending in the dynasty of the Hans (202 B.C.-220 A.D.). (14:586)

India began bronze casting in the Indus Valley (Harappa) during the 3rd millennium B.C. (14:586)

The art of casting became known in Minoan and Mycenaean times (2nd millennium B.C.). The Etruscans, during the 6th and 5th Centuries

B.C., working in the Greek manner, also cast many bronzes. During the 1000 years between the fall of the Roman Empire and the Renaissance, the Christian Church controlled the bronze work and all the Medieval art. (14:586)

The art of casting advanced through the Renaissance where statuettes and medals were made until our present times where bronze is used mainly for industry with a minority of use in the arts. (14:588)

Leuzinger points out in his book on Africa many interesting observations of the great works of the early Benin bronze periods. He says that it was discovered by the British on one of their expeditions to African Nigeria, that many wonderful bronzes existed in the Benin area. These bronzes were brought back to Europe in 1897 and a history of the origin of these pieces was speculated about. The most popular belief is that the process of bronze casting was introduced to the Benin during the reign of King Oba Ogula, about 1400. This introduction came from the north, Ife, where its introduction had come from the north in Egypt, probably through trading done between Ife and the northern areas of Africa. (11:42)

Further information, concerning tin bronze and its use is given by Dudley Easby, Jr. (6:72-81) In an article, Mr. Easby cites various recordings and excavations in the New World (North and South America) where metal processing was carried on. The metals being used both in their natural state and alloyed.

According to Mr. Easby, (6:72) stratigraphic, geological and paleontological evidence, as well as carbon-14 dating places the earliest known metal artifacts in the New World as those of the "Old Copper"

culture that flourished in the upper Great Lakes region of North America, beginning about 4000 B.C. and lasting for around 2000 years longer. The first metal used here was that of native copper. Native copper is copper occurring in nature as a relatively pure metal rather than copper which had to be extracted from an ore by smelting. In this natural state, copper is sufficiently soft and malleable to shaped by hammering. The implements of the "Old Copper" culture included knives, chisels, axes, harpoon heads, awls, and projectile points. The artisans derived the shapes of these utilitarian objects for the most part from prototypes made of stone, bone, horn, or shell, although they were aware of the different properties of the metal and made use of these differences, also.

Another area of fine copper work was in the region north of Mexico. This was the area of the Hopewell culture. The most notable examples of their work came from Mound City and nearby sites in Ohio and were made sometime around 2000 A.D. These artisans also did not know how to solder nor cast, but did strictly hammered, repoussed, riveted, and hammer-welded objects.

By the time the Spaniards arrived Peruvian metalworkers had already begun to cast in bronze their weapons, and tools.

Easby suggests that the discovery of bronze as an alloy in Peru and other areas in South America happened by chance through possible impurities in the copper...mainly tin. Tin may be found in the very area that copper is found and is sometimes mixed in with the copper ore.

Bronze objects have also been found in Bolivia, Chile, and

Argentina. "Indeed, the first bronze in the New World was probably made about A.D. 700 in Bolivia, an area still famous for its tin deposits."

Metallic money appeared in Ecuador and northern Peru about 100 A.D. or slightly earlier. This money consisted of small copper axe blades, which were too thin for any practical purpose and were used as a medium of exchange. Many of these same type of axes have been found in western Mexico and the consensus is that the idea possibly spread from Ecuador.

A gold-copper alloy known as tumbaga was widely used in Columbia, Panama, and Costa Rica.

Casting by the lost wax method was known to these early New World people and practiced in various ways and with various metals, alloys, and bi-metals. (6:72-81)

Properties. The properties which the addition tin gave to copper and have endeared bronze to its admirers throughout the ages are, besides the greater strength and hardness of the alloy, and the warmth and beauty of its color, its extraordinary resistance to corrosion. Hoyt shows in his graphs that the copper-tin alloys better withstand the weather than do the copper-zinc alloys (brass). (7:232) The tin bronzes can take on wonderful, exciting, and permanent patina through the treatment with certain chemicals.

The tin bronzes are alloys of tin and copper. The percentages used in this study are Sn 12% and Cu 88%. The melting point of this alloy is 1797 degrees F.

As the tin content of the bronze is increased, the stronger the

metal is, but the less elasticity or resilience it has. This also lowers its fusibility. This less elasticity is due technically because this increase of tin is a structural formation of dendrites, tree-like structures of hard-core crystals. (14:884)

An explanation of "shrinkage porosity" as given by Nieuwerkerken, shows the cause and remedy of this situation in his terms.

When any part of the casting reaches the liquidus temperature... the point at which solidification begins...nuclei are formed. These grow into crystals. Upon further cooling, these crystals continue to increase in size, and spread out until they touch one another and form branches leaving irregular channels which, are apt to leave voids which entrap the still liquid metal. This is the cause of "shrinkage porosity." One remedy is to make provisions for progressive solidification zones and judicious use of gates which keep on feeding molten metal from risers in the mold with sufficient capacity to fill the voids. (14:584)

According to Ney, in order to cut down the shrinkage porosity, in simple centrifugal casting, one could enlarge the main feeding sprues, larger than any part of the piece, or place metal reservoirs (larger areas than the rest of the sprues) within an eight of an inch of the piece. This will trap any shrinkage porosity which may occur. (12:20)

Tin bronze should be slightly over-heated when cast. It should be melted in an oxidizing atmosphere. Any oxidation rises to the surface and can be taken off.

The primary use of this alloy is in Industry for bolts, gears, bearings, and ship's fittings. For many centuries tin bronze has been used by private individuals and companies as a medium for cast sculpture, bells, door-pulls, and doors. (4:6)

Silver

Silver's beauty and resistance to corrosion have always made it a precious metal, desirable for jewelry and for ceremonial articles, and

its use can be traced back to the earliest civilization in Egypt.

History. Spain was noted in ancient days for its silver mines, as Asimov notes in his essay. In the 5th Century B.C., the discovery of silver mines in Athenian territory helped make Athens rich and powerful and thus contributed to the golden age of Pericles. The Romans knew silver as argentum, from which its chemical symbol, Ag, is derived. The medieval chemists connected silver with moon and called the metal "selene," after the Greek moon goddess, or "luna" after the Latin counterpart. Ores containing silver are still called "seleniferous. (1:489) The alchemists gave it the mystic symbol of the crescent moon. (3:152)

Properties. The melting point of pure silver is 1761 degrees F. The silver alloy included in this study is called sterling silver and its melting point is 1640 degrees F. The alloyed metal content is 92.5% Ag, and 7.5% Cu. Other alloys of silver are coin silver (U.S.), 90% Ag, and 10% Cu; and Mexican silver (a very low grade of silver alloy), usually has less than a 90% Ag. (4:34)

"The Americans have produced 85% of the total mined silver since 1492." North America alone has produced 60%. Mexico is far in the lead, U.S., and Canada, in that order. (4:3)

About three-fourths of the world's production of silver is used for monetary purposes. The leading industrial use is for tableware and jewelry with the photographic industry the second largest industrial consumer (silver compounded with bromine or chlorine forms the silver salts which register light in values on films and plates). Silver is an important substitute for copper, nickel, aluminum, and tin when these cheaper materials are unavailable. Silver is resistant to organic acids and so often is

used to line food processing equipment. (4:3) Hoyt reports that silver resists corrosion but combines readily with sulphur to form silver sulphide, a surface oxidation. (7:281)

Silver is almost a pure white metal. It is a lustrous metal and like gold is extremely soft in its natural state and is usually alloyed with copper. Silver is easily worked, takes various polishes, and finishes readily. Its color is compatible with many other materials such as wood, bone, gem stones, and other metals. It may be cast hard soldered, or joined by fusion.

Campbell describes other interesting properties of silver. Silver leaf can be beaten to a thickness of 1/100,000 of an inch, and one ounce can be drawn out into a wire thirty miles long. At this point it readily transmits light. Spring silver, which is heard of occasionally, is sterling silver that has been reduced as much as ten times its original (last annealed) thickness by rolling or drawing to harden it. (4:4)

Campbell suggests various ways to test metals for their silver content. One method is to file a deep notch in the piece to be tested and apply a drop of nitric acid. If the metal is sterling silver the acid will turn the place a cloudy cream. If the metal is plated ware, the acid will turn the base metal green. If the metal is nickel silver, the acid will turn it green. If the metal is coin silver, the acid will turn it a dark or oxford grey or black. Another test could be that when silver is pickled, it turns a glittering white, while nickle silver takes on a dull grey finish. A test for pure silver against sterling silver is to heat the silver to a light red and let it cool. The pure silver will remain white. The sterling silver will turn a dark grey or black when treated in this same way. (4:4)

Aluminum bronze

Very little is written about aluminum bronze and its history, but the available information is summarized in the following.

History. Aluminum was first isolated in an impure form in 1825 by H. C. Oersted, but F. Wohler is usually credited with obtaining it pure two years later. (14:883)

Properties. Camm discusses aluminum and aluminum bronze briefly in his book. According to him, the melting point of pure aluminum is 1220 degrees F. Aluminum bronze is an alloy of aluminum and copper, 5% Al and 95% Cu. The melting point of aluminum bronze is 1258 degrees F. (3:18)

The addition of copper to the aluminum helps to increase the oxidation-resistance of the metal. The alloy does have excellent corrosive resistance, and has a high tensile strength and clean casting qualities. (4:6) The acid and oxide resistance of this alloy lends itself as a good jewelry media. Sometimes the alloy is called French Gold. This is due to the alloy's color resemblance to yellow gold.

Aluminum bronze is much lighter in weight than the other copper-base alloys. It is primarily used in industry.

Silicon bronze

As with aluminum bronze, not much information is available about silicon bronze, but the following is a summary of what has been found.

History. Silicon is an element similar to carbon in properties, discovered in 1823 by J. J. Berzelius. (1:483)

Properties. The element-metal, silicon, is blue-gray and brittle with a metallic luster. It is considered a metalloid, that is, it has both metallic and non-metallic properties. (1:483)

Silicon is the second most common element on the earth's crust, making up 25% of it. The chemical symbol of silicon is Si. Its melting point is 2588 degrees F. An interesting fact is that the boiling point of silicon is 4271 degrees F. (1:483)

The melting point of silicon bronze (Duronze II) is 1830 degrees F. Silicon bronze is an alloy of silicon and copper in the percentages, Si 3% and Cu 97%. (7:235) Hoyt further points out that this alloy is of the most versatile groups. Besides having the strength of mild steel and a corrosive resistance practically equal to that of pure copper, they are highly rated for malleability, fatigue resistance weldability, and forming properties. The use is mainly for industrial purposes, such as, machine parts, gears, and shafts. (7:235)

II. REVIEW OF RELATED STUDIES

A brief exploration into a few related studies seems significant at this point. Jewelry designing is a highly individualistic form of art. Some jewelers are experimentalists, some are expressionists, still others are realists, and all are designers in their own rights. An aesthetic end value is their goal.

In an article by Abe Karlikow about the jewelry-designer, Torun, statements of meaning are given by the artist, herself. Torun's philosophy of jewelry concerns itself with the individual for which the piece is to be made. To Torun the "woman is a living sculpture, but little jewelry takes this into account." She searches for forms in her jewelry that "begin with the woman." Body contours and volume are clearly in her mind. A point which Torun is quoted in saying is that "almost all jewelry is flat, meant to be seen from the front only. It has no volume, no back,

no true involvement with the wearer. It just lies there. (8:20-21)

Another jewelry-designer involved with the idea of jewelry as sculpture or part of sculpture, only from a different angle of approach, is Bob Winston of Arizona. Nik Krevitsky gives a brief, but interesting summary of Winston's methods and philosophy for jewelry creating.

Winston uses the lost wax centrifugal casting method in creating his jewelry. He forms his wax models meticulously and the polished or texture surface of the wax is the desired finish of what he calls "wearable sculptured jewelry." Winston has experimented with cast forms since 1945. He has perfected his casting and has tried through this media, to create organic and natural forms which, he feels, have a special warmth and appeal. (9:10-13)

An experimentalist in the area of jewelry designing is Helen Diemert, a high school art teacher. She is able to invoke a spark of creativity in her students by having them experiment with the accidental forms caused by pouring molten wax over ice and then casting these forms in the centrifugal lost wax process. She believes that through the use of ice and iced water with the molten wax, her students can create a "rich diversity of interesting, rhythmic forms, and a delicacy and thinness of forms." After the forms are made by the accidental method, many variations can be made; additions and subtractions. The concern here, unlike Torun, is for the end aesthetic quality of the piece alone, not in relation, necessarily, with the person for whom it is being created. (5:5-10)

A carved-out method of creating designs for jewelry was illustrated in an article by John Leary of San Jose State College. He proposes this method because of its simplicity. It doesn't require any special equipment,

other than some form of heating the metal. Leary's method involves at least two sections of a mold which can be carved from blocks of investment. The desired metal is melted directly in the carved-out areas and the second section of the mold is placed gently, but firmly, over the molten metal, forcing the design into the carved-out areas. This is a very direct method. Much designing and creativity can go into even this simple form of jewelry-making. (10:9-11)

There are many ways to arrive at designs for jewelry, through accidental, planned, and re-planned processes, and through philosophical, casual, and consumer appeal. They may or may not have aesthetic value to all peoples, but they individual must feel this for his jewelry to be valid as a form of art.

CHAPTER III

MATERIALS AND PROCEDURES

Through-out this study, various references have been made to the materials and procedures used. The necessity of the proper materials involved in the carrying out of the specific experimentations has been shown through the explanations of the various procedures. Without the proper materials available, this study could not have been conducted with positive results. The materials and their involvement with the procedures are discussed in this chapter.

I ALLOYS

The selected alloys of this study possess their own particular characteristics and properties which are validly adaptable to the jewelry creating processes used in this study. This adaptability has been shown through the experimentations with these various alloys and the positive results obtained.

TABLE I

NAME OF ALLOY	PERCENTAGES OF METALS USED					
	Cu	Sn	Sb	Ag	Al	Si
Britannia Metal	1.5%	91%	7.5%			
Tin Bronze	88%	12%				
Silver Alloy	5%			95%		
Aluminum Bronze	95%				5%	
Silicon Bronze	97%					3%

NAME OF ALLOY	PROCESS BY WHICH ALLOY CAN BE CAST		
	Centrifugal	Steam	Gravity
SnSbCu		*	*
SnCu	*	*	
AgCu	*	*	
AlCu	*	*	
SiCu	*	*	

NAME OF ALLOY	MELTING POINTS OF ALLOYS						
	Alloy	Cu	Sn	Sb	Ag	Al	Si
SnSbCu	527	1981	450	1167			
SnCu	1797	1981	450				
AgCu	1640	1981			1761		
AlCu	1258	1981				1220	
SiCu	1830	1981					2588

NAME OF ALLOY	PERCENTAGES CONVERTED TO WEIGHTS					
	Cu	Sn	Sb	Ag	Al	Si
SnSbCu	4dwt	9dwt 2gn	18gn			
SnCu	17dwt 14gn	2dwt 10gn				
AgCu	1dwt			19dwt		
AlCu	19dwt				1dwt	
SiCu	19dwt 10gn					14gn

II. MATERIALS USED

The selection of the materials necessary in this study have been limited in their necessity by the specific methods of casting employed.

The following are the materials utilized in this study:

1. Kerr wax wires, sheets, and blocks
2. Alcohol
3. Vacu-film debubbler
4. Investment
5. Cuttlebone
6. Asbestos block and sheet
7. Binding wire
8. Asbestos powder



FIRGURE 1
MATERIALS USED

III. TOOLS AND EQUIPMENT USED

Specific equipment was necessary to conduct the proper experiments with the selected alloys of this study. Under the limitations imposed upon by the conditions prevalent in the laboratory, the experiments were conducted as idealistically as possible.

The following equipment was employed:

- | | |
|-------------------------------|---------------------------------|
| 1. Alcohol burner | 10. Oxyo-acetylene torch |
| 2. Waxing tools | 11. Kiln |
| 3. Ring mandrel | 12. Centrifugal casting machine |
| 4. Flask cylinders | 13. Hand-steamer |
| 5. Tin can | 14. Asbestos block and sheet |
| 6. Brush | 15. Crucibles |
| 7. Sprue-former | 16. Files |
| 8. Tongs for flask | 17. Emery paper |
| 9. Prestolite acetylene torch | 18. Tripoli and rouge |



FIGURE 2

TOOLS AND EQUIPMENT USED

IV. METHODS

There are three methods, or processes, employed in this study: (1) Centrifugal casting, (2) Gravity casting, and (3) Steam casting. With the alloys of tin bronze, aluminum bronze, and silver, the steam-gravity and centrifugal casting methods are best utilized. In the instance of silicon bronze, because of its rapid rate of solidification, the centrifugal method of casting was the only process used. Britannia metal, because of its slow rate of solidification, must be cast in the gravity and steam-casting methods. These were the two processes resorted to in the case of this alloy.

V. GENERAL PROCEDURES

The following outline shows the general procedures used in the creation of the jewelry pieces for this thesis.

1. Design piece
2. Preparation of method for casting
3. Alloy metals
4. Cast
5. Finish piece

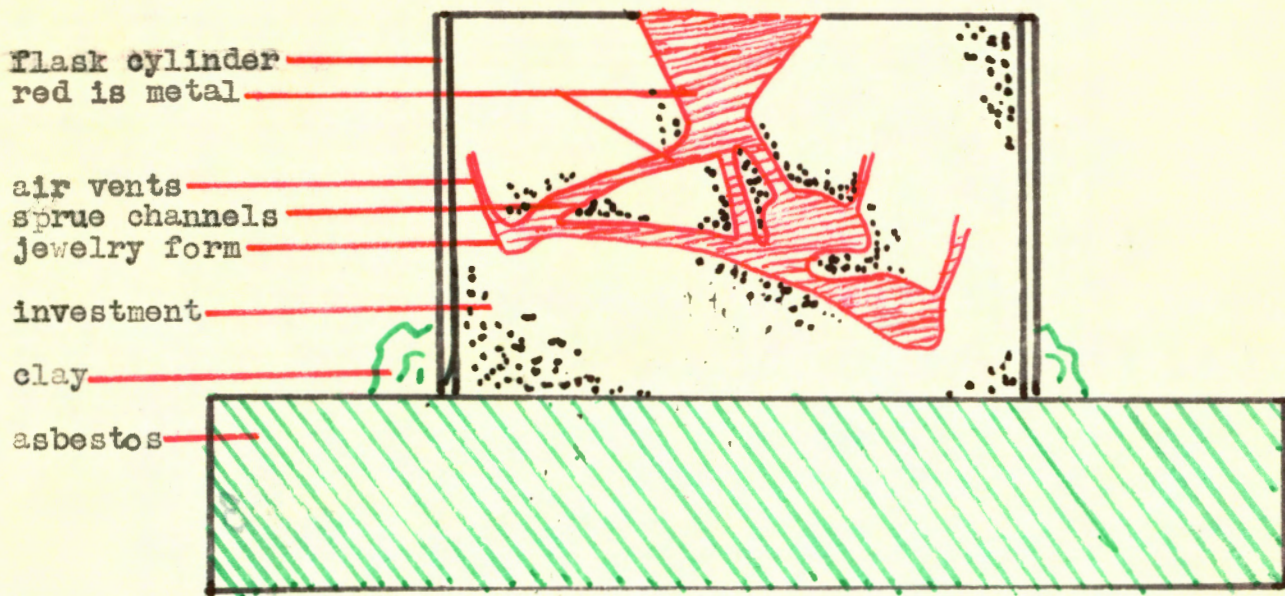


FIGURE 3

GRAVITY CAST METHOD

After the wax is burned out in the kiln, the flask cylinder is set sprue-channel up on an asbestos block. The alloy is then melted in a crucible and poured into the opening, or else it may be melted directly in the sprue opening. The trapped air in the passages escapes through the air vents, allowing the metal to take its place. The metal is allowed to solidify and is then removed from the investment.

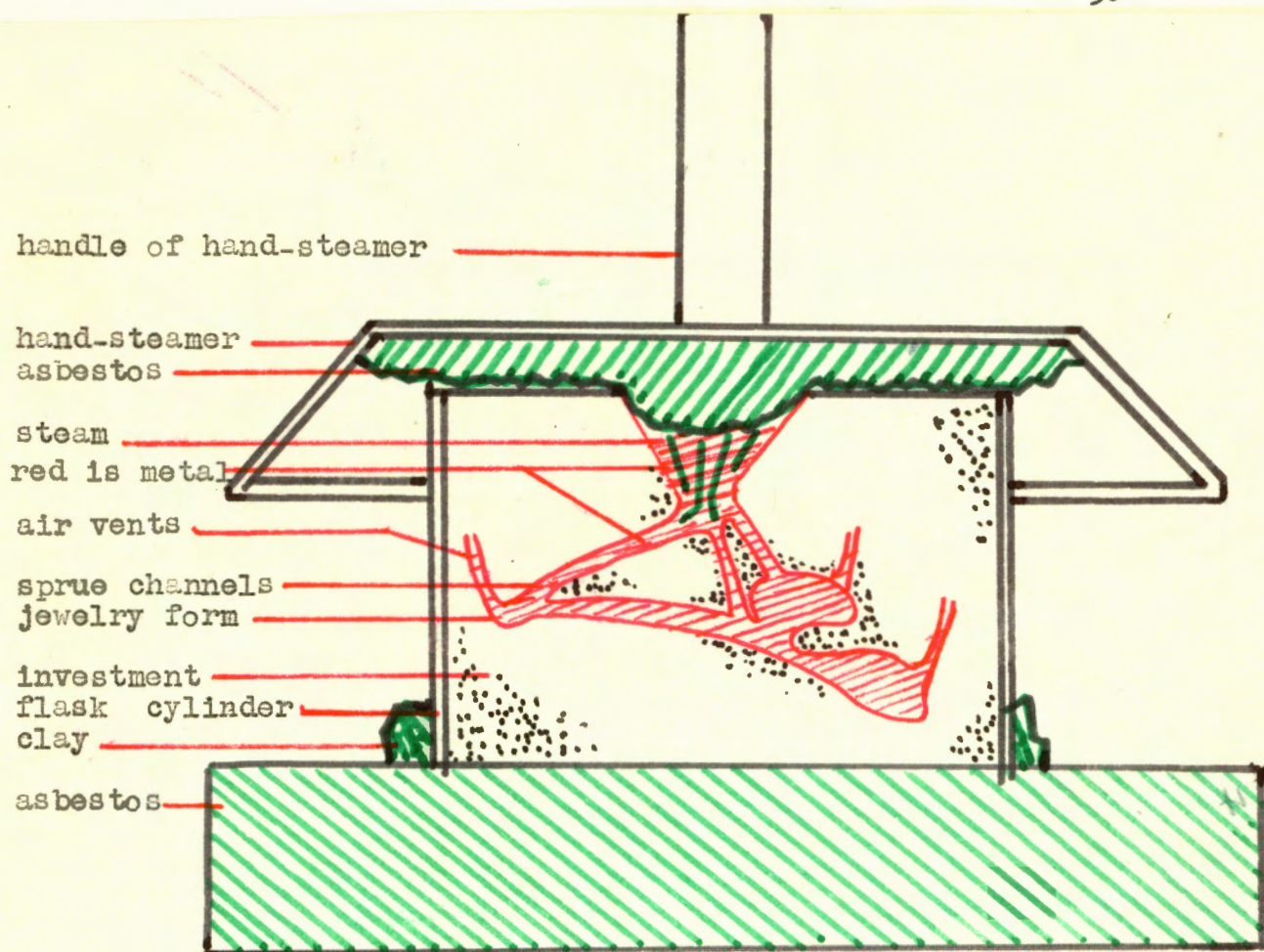


FIGURE 4

STEAM CAST METHOD

Variation number one in the steam cast method is illustrated above. In this instance, the model was made of wax, invested, and burned-out. The flask cylinder is set sprue-channel up on an asbestos block. The alloy is then melted in a crucible and poured into the opening, or melted directly in the sprue-channel. Immediately, steam pressure is exerted on the metal by means of the hand-steamer, forcing the metal into all the areas of the form. The trapped air in the passages escapes through the air vents, allowing the metal to take its place.

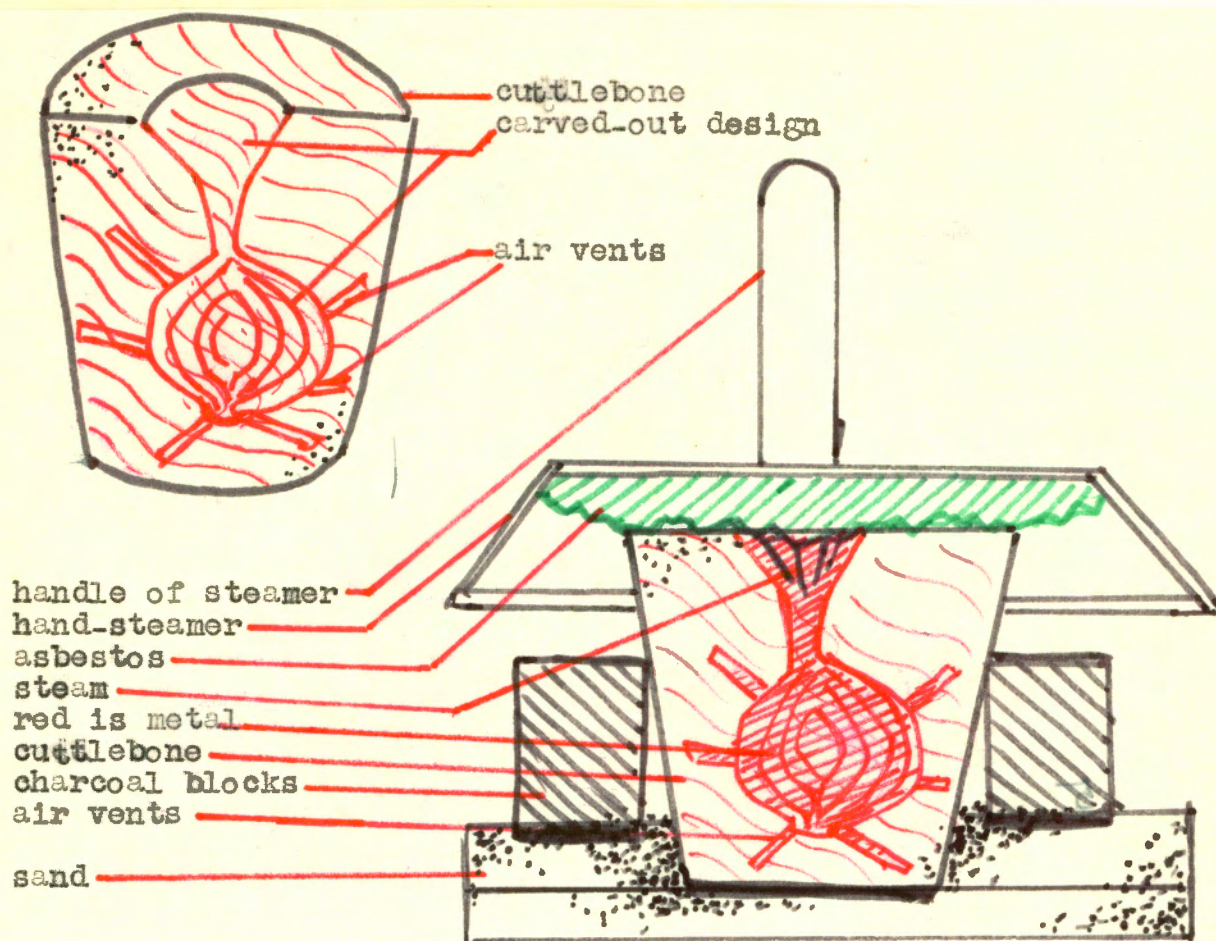


FIGURE 5

STEAM CAST METHOD

Variation number two in the steam cast method is illustrated above. In this instance, the design was carved into the substance of cuttlebone, the bone of the cuttlefish. The design was carved into two pieces of cuttlebone the same size. These form the two sections of the two-piece mold. The two sections are then vented and bound together with binding wire. The complete mold is then set into sand and braced with charcoal blocks. The alloy is melted in a crucible and poured into the sprue opening. Immediately, steam pressure is exerted on the metal by means of the hand-steamer, forcing the metal into all the areas of the form.

The trapped air in the passages escapes through the air vents, allowing the metal to take its place in the form. By first charring the surface of the carved-out area with the flame of a candle, the charred surface will act as a flux, allowing a smooth passage of the metal to all parts of the design.

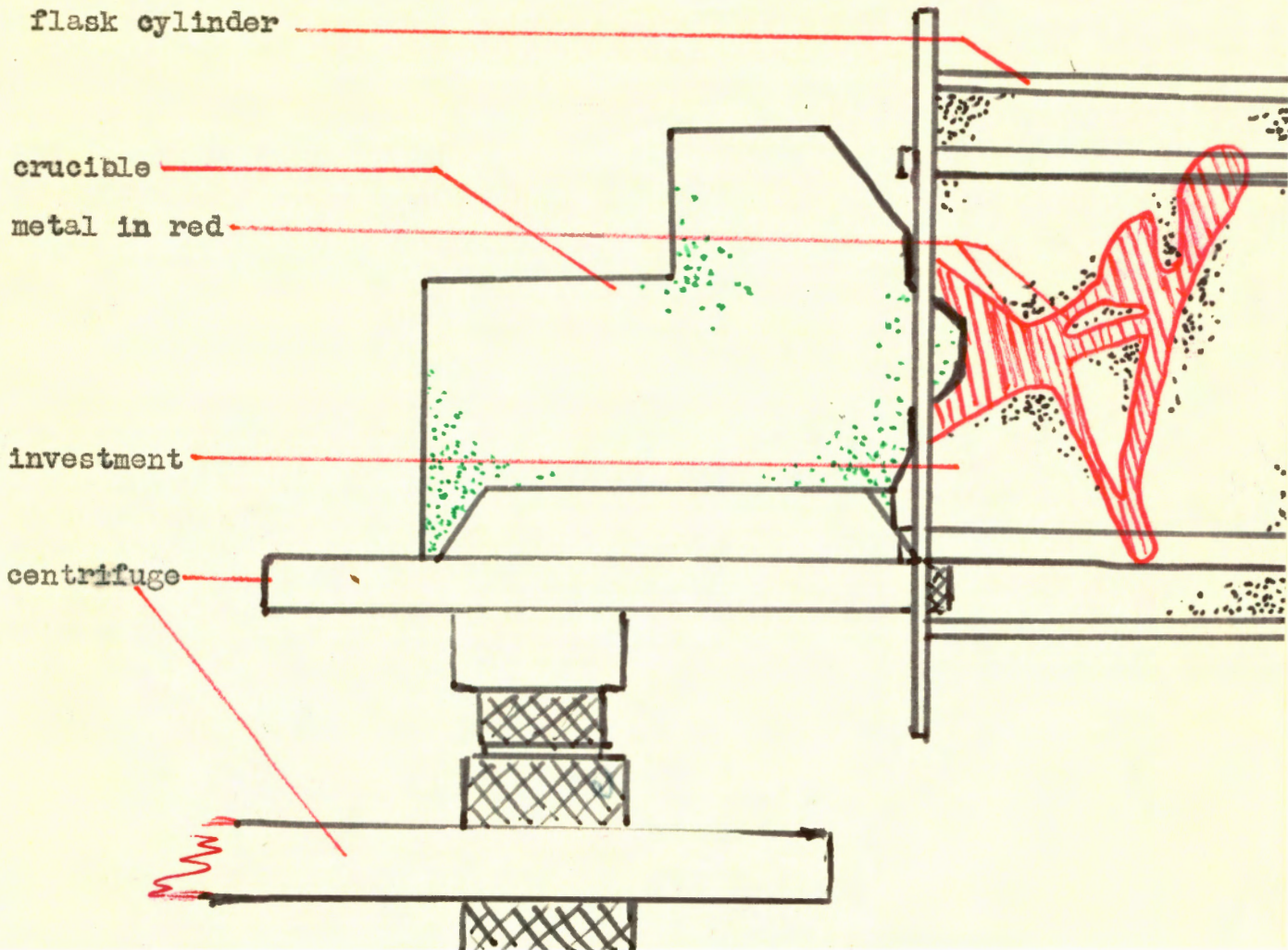


FIGURE 6

CENTRIFUGAL CAST METHOD

After the wax is burned-out, the flask cylinder is placed in the centrifuge, fitting into place in front of the crucible. The nose of the crucible should fit directly in line with the sprue-base opening of the flask mold, allowing a direct flow of the metal into the sprue-channels.

The centrifuge is balanced, wound the desired number of times, and held by the spring-tripper. The alloy is melted in the crucible to a completely molten, flowing consistence. The spring is released, and centrifugal force causes the molten metal to flow into the mold.

The metal is allowed to solidify and is then removed from the investment by lowering it into a pan of water. The water disintegrates the investment, leaving the metal.

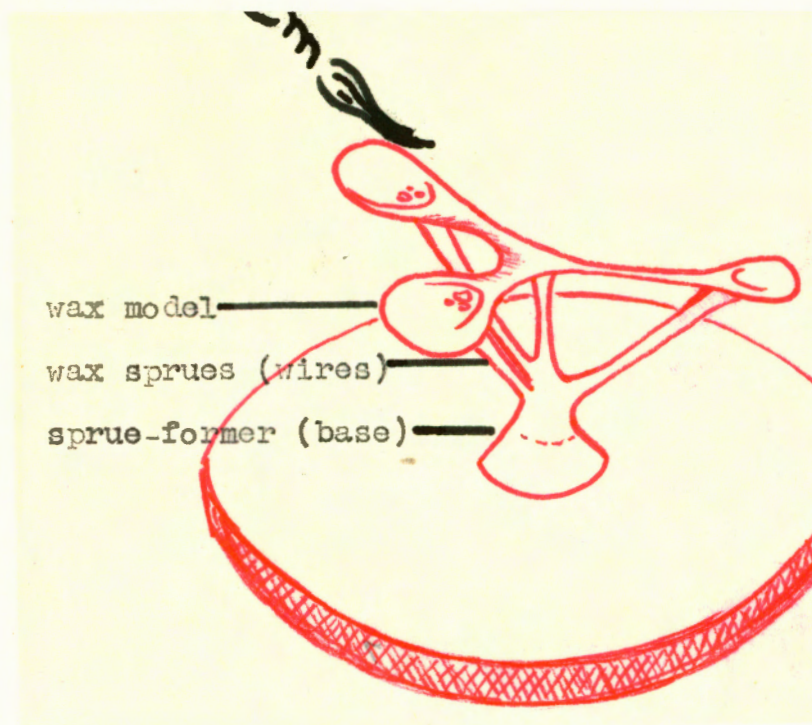


FIGURE 7

SPRUEING PROCEDURE AND PREPARATION FOR INVESTING

1. Form piece in wax as it should appear in the finished jewelry piece.
2. Sprue piece for investing. The attachments of the wax wires should be made to the largest areas of the wax model and then be brought together to the sprue-former. The attachments must be smooth-cornered to insure a smooth flow of molten metal to the piece.
3. Paint the wax model and sprues with vacu-film to reduce the surface tension of the wax.
4. Let the vacu-film dry and mix a small amount of investment.
5. Paint the wax model and sprues with the investment and let it set up.

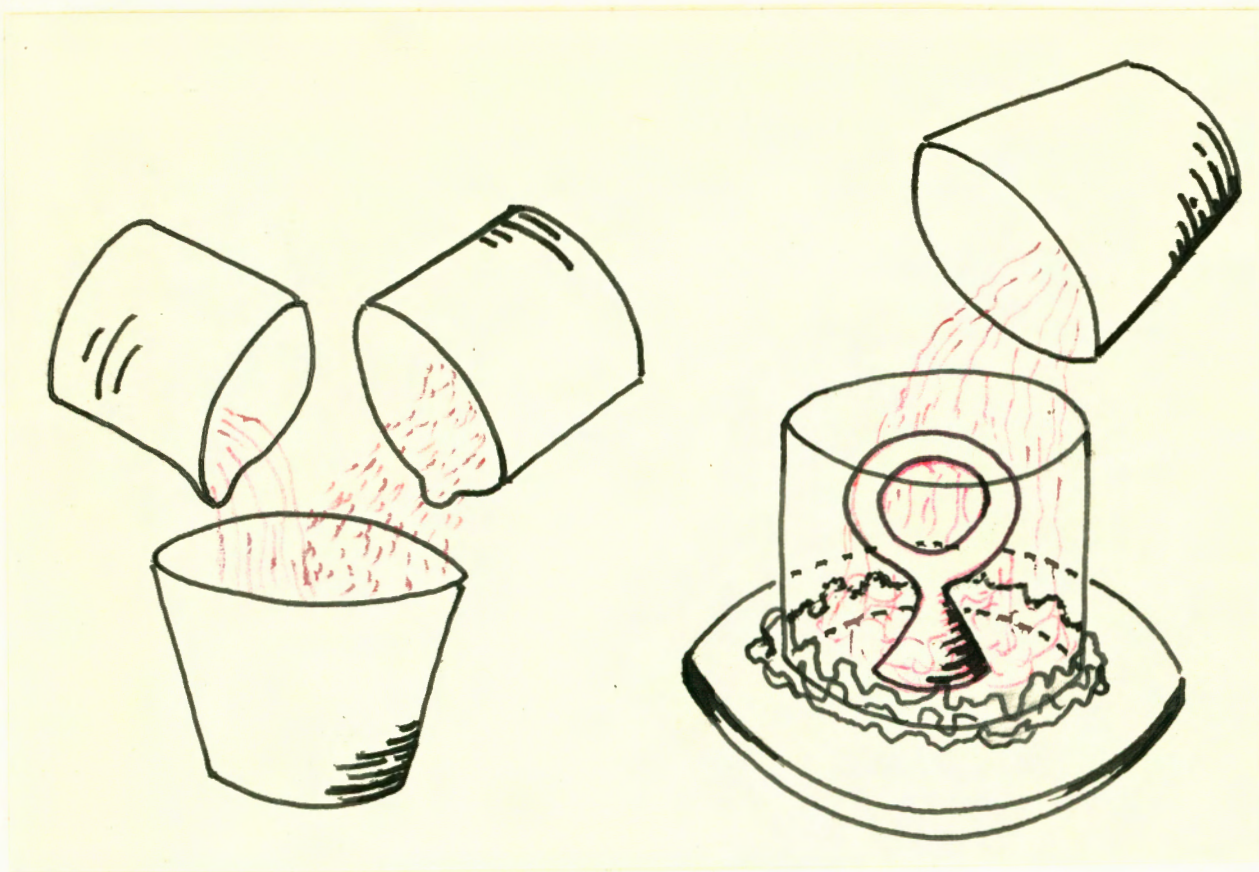


FIGURE 8

INVESTMENT PROCEDURE

1. Mix the investment by adding the powdered compound to water until a creamy consistency is reached.
2. Pour the investment into the flask cylinder, around the wax model and sprues, until the mixture reaches the top. (Clay is put around outside of flask to keep the investment from leaking out at the bottom).
3. Tap side of flask after the investment has been poured in order to force to the top any air bubbles that may have gotten trapped under the model.

VI. SPECIFIC PROCEDURES

Because of the differences in the properties of the selected alloys, the methods utilized in the casting of these alloys, and the designs created for the jewelry pieces, this chapter is devoted to explaining the specific procedures for each of the selected alloys.

Britannia Metal

- I. Method: Gravity Casting
 - A. Designing of piece
 - B. Preparation of method
 - 1. Creation of the design in wax
 - 2. Investment of piece
 - 3. Burn-out of wax in kiln
 - C. Alloying of metals: Sn, Sb, and Cu
 - D. Casting of piece
 - E. Removal of piece from investment
 - F. Finishing of piece
- II. Method: Steam-gravity Casting
 - A. Designing of piece
 - B. Preparation of method
 - 1. Carving out of design in cuttlebone
 - 2. Binding cuttlebone mold pieces together
 - C. Casting of piece
 - D. Removal of piece from mold
 - E. Finishing of piece

The first method employed in the casting of this alloy was the gravity process.* The inspiration for this design came from the interesting shape of the cherry blossom bud, cut in half. Nature's shape was re-designed for the creation of this particular jewelry piece.

In preparation for the casting of this piece, the two halves of the pendant were formed separately in wax. The pieces were sprued, air vents were added, and the pieces were invested separately in two different flask cylinders.** Both flasks were placed in the kiln and the wax was burned out.

* Figure 3

** Figure 7 and 8

For one side of the pendant a commercially made alloy was used. For the other side the following metals were alloyed: 1.5% Cu, 91% Sn, and 7.5% Sb.* The resulting alloy was poured into the sprue-channel of the flask cylinder, the gravity cast method.

In each cast, the flask cylinders were left to cool until the Britannia metal became solidified. Britannia metal flows best if the flask cylinder is allowed to cool slightly before the casting process is performed. Also, the metal may be successfully cast in a cold flask mold. By having the flask cylinder cooler than the temperature of which it is when removed from the kiln, the poured molten metal speeds up its solidification and cooling.

The pendant halves were removed from the investment, the sprues detached, and the pieces both finished. A soft looking patina on the surface of the Britannia metal was created by brushing "pickle" solution in the areas intended to be darkened.

After assembling the two halves of the pendant, a decision was made to include a contrasting metal with the pewter. A center piece for one of the two halves and two beads were cast in aluminum bronze. The centerpiece is attached by piercing the one side and inserting the section through, and clamping the piece into position.

Because of its very low melting point and slow rate of solidification, Britannia metal cannot be successfully centrifugally cast, therefore, the second method which was employed is that of steam casting.**

The medium of cuttlebone was used for the carving out of a design

* Appendix

** Figure 5

for this jewelry piece. This type of steam casting involved a two or more part mold. A two-part mold was used in this instance. The inspiration for the design came from the cuttlebone's natural pattern.

In preparation for this piece, a design was carved into matched sections of cuttlebone. These were to be the two parts of the mold. After the design was carved, air vents and channel through which the molten metal would blow were carved. (Air vents are necessary in the steam cast method. When the molten metal is poured into the mold and pressure is applied, these air vents are a means of escape for the trapped air in the mold.)

The two pieces of the mold were then placed together and tied securely with binding wire. The mold was then placed, channel up, in sand and braced with charcoal blocks. The Britannia metal was alloyed in a separate crucible,* and poured into the channel of the mold. Pressure was placed on the metal by means of steam.** The cuttlebone was left to stand until the alloy solidified. The mold was then separated and the cast piece removed. The air vents, now metal, were removed by cutting, and the jewelry piece was given a final polish and attached to a necklace designed in accordance with the Britannia metal pendant.

Tin Bronze

I. Method: Centrifugal Casting

- A. Designing of piece
- B. Preparation of method
 - 1. Creation of design in wax for basic form
 - 2. Spruing and investment of piece
 - 3. Burn-out of wax in kiln
- C. Casting of basic form in silver
- D. Removal of piece from investment
- E. Finishing of form

* Appendix

** Figure 5

- F. Re-designing in wax for second alloy
- G. Preparation of method
 - 1. Spruing and investment of piece
 - 2. Burn-out of wax in kiln
- H. Casting of second alloy
- I. Removal of piece from investment
- J. Finishing of piece

II. Method: Steam Casting

- A. Designing of piece
- B. Preparation of method
 - 1. Creation of design in wax
 - 2. Spruing and investment of piece
 - 3. Burn-out of wax in kiln
- C. Casting of piece
- D. Removal of piece from investment
- E. Finishing of piece

The processes used in the two explorations with this alloy were centrifugal casting* and steam casting.** The former process involved the use of a commercially made tin alloy of 88% Cu and 12% Sn, while the latter process was carried on with an experimentally formed alloy of 60% Cu and 40% Sn. The tin alloys in both instances cast with positive results... a complete absence of porosity.

The first piece, involving the commercial alloy, was of a bi-metal construction. The basic design was formed in silver, with the second alloy being that of the commercial tin bronze.*** The first metal created the basic form for a pendant. The pendant was taken from the mold and finished as far as the polishing stage. It was then re-designed to incorporate the alloy, tin bronze, in the second casting. To bi-metal cast this piece, the wax had to be involved with the first metal in such a way that the second metal cast would stay in place without soldering.

The wax involved model was then sprued so that the sprues extended from the top of the pendant. These sprues were brought together at the

* Figure 6

** Figure 4

*** Appendix

other ends and attached to the sprue-former. The model and sprues were then painted with vacu-film debubbler and investment,* and then invested in a flask cylinder.** The wax was burned-out and the flask was removed from the kiln and placed in the centrifuge.*** After casting the piece a second time, the sprues were removed and these rough areas filed. During the finishing processes, the piece was given a patina through the use of sulphurated potash. The raised surfaces were polished, and the recesses left dark. The contrast of the bi-metale silver and bronze colors added an interesting highlight to the design of the piece. The design inspiration for this piece developed from the idea of the movements and anxieties of people.

The second piece, that of the experimental alloy, was first created in wax, sprued, invested, burned-out, and then steam cast.**** For this piece, the metals of tin and copper were alloyed in a crucible and poured into the cast and given pressure by the use of the hand-steamer. The piece was removed from the flask cylinder, the sprues removed, and the piece smoothed. It was then fused onto a necklace of silver. No solder was used in this joining, only the heat of the acetylene torch caused this fusion. The piece was not given a patina, but the necklace and pendant were polished to a high sheen. The design of the necklace was inspired by the pendant, itself. The inspiration for the pendant had come from the basic shape of a cherry tree leaf. The coloring of this alloy is a silver-red. When placed near a brassy yellow, the pendant looks silver, but placed with silver, the pendant seems to be reddish.

* Figure 7

** Figure 8

*** Figure 6

****Figure 6

Silver

- I. Method: Centrifugal Casting
 - A. Designing of piece
 - B. Preparation of method
 - 1. Creation of design in wax
 - 2. Investment of piece
 - 3. Burn-out of wax in kiln
 - C. Casting of piece
 - D. Removal of piece from investment
 - E. Finishing of piece and setting of stone

- II. Method: Steam Casting
 - A. Designing of piece
 - B. Preparation of method
 - 1. Creation of design in wax
 - 2. Investment of piece
 - 3. Burn-out of wax in kiln
 - C. Alloying of metals
 - D. Casting of piece
 - E. Removal of piece from investment
 - F. Finishing of piece

The process used in the casting of the first piece of silver alloy was Centrifugal casting.* The alloy, 95% Ag and 5% Cu, was commercial sterling silver. The jewelry creation was that of a ring, set with an alexandrite faceted stone. The design of the ring is influenced by the planes of the faceted stone and the round shape of the stone top. The unusual style of the ring shank was inspired by the comfort obtained in wearing this particular shank formation. After casting, the ring was smoothed and polished, the stone set, and the surface given a dark patina by application of sulphurated potash. The raised surfaces were polished and the recesses were left dark.

The process used in casting the second piece was that of steam casting.** The metals, 95% Ag and 5% Cu, were alloyed in a separate crucible and poured into the opening of the sprue-channel. The piece was removed from the investment, the sprues detached, and the surface given a smoothing and polishing. The recessed areas were darkened by the action of

* Figure 6

** Figure 4

of sulphurated potash, and the raised areas were given a high sheen. The piece, a key fob, was attached to a black cord and key ring.

Aluminum Bronze

- I. Method: Centrifugal Casting
 - A. Designing of piece
 - B. Preparation of method
 - 1. Creation of design in wax
 - 2. Investment of piece
 - 3. Burn-out of wax in kiln
 - C. Casting of piece
 - D. Removal of piece from investment
 - E. Finishing of piece
- II. Method: Steam Casting
 - A. Designing of piece
 - B. Preparation of method
 - 1. Creation of design in wax
 - 2. Investment of piece
 - 3. Burn-out of wax in kiln
 - C. Alloying of metals
 - D. Casting of piece
 - E. Removal of piece from investment
 - F. Finishing of piece

The first piece we created in the commercial aluminum bronze alloy of 95% Cu and 5% Al, and had an owl for its inspiration. The piece, a pendant, was formed of wax and cast in the centrifugal casting method.* The pendant was removed from the investment, the sprues detached, and the pendant smoothed and polished. No patina was applied to the surface.

The second piece was made from an experimental alloy using the same formula as the commercial alloy, 95% Cu and 5% Al. The inspiration for this design was a tree branch. The resulting creation developed into a hair ornament. This piece was cast in the steam cast method.** The aluminum bronze is a lighter metal in weight than the other alloys used in this study. It works very well for hair ornaments or other jewelry

* Figure 6

** Figure 4

items which should be comparatively lighter in weight. A patina was applied to the surface through the use of the chemical, sulphurated potash, and the surface was polished as much as could be reached.

Silicon Bronze

- I. Method: Centrifugal Casting
 - A. Designing of piece
 - B. Preparation of method
 1. Creation of design in wax
 2. Investment of piece
 3. Burn-out of wax in kiln
 - C. Casting of piece
 - D. Removal of piece from investment
 - E. Finishing of piece and adding of beads
- II. Method: Centrifugal Casting
 - A. Designing of piece
 - B. Preparation of method
 1. Creation of design in wax
 2. Investment of piece
 3. Burn-out of wax in kiln
 - C. Casting of piece
 - D. Removal of piece from investment
 - E. Finishing of piece and attachment to key chain

Centrifugal casting was employed as a process for both of the two silicon bronze jewelry pieces created.* The alloy in both instances was Duronze II, a commercially formed alloy, 97% Cu and 3% Si.

The first piece, a three-piece pendant design, was cast, using the oxygen-acetylene gas torch equipment. Some shrinkage porosity appeared on the surface. The color is a pinkish-yellow, not of the brass yellow tone. The inspiration for this piece had come from shapes of certain plant leaves.

The second piece was that of a key fob pendant. The inspiration for this pendant came from the idea of a couple, a man and a woman in love. This piece was also cast using an oxygen-acetylene gas torch. Again,

* Figure 4

** Figure 6

shrinkage porosity appeared on the surface at the sprue attachment areas as had the first piece cast of silicon bronze. This pendant was attached to a black-corded key ring and polished to a high luster. No patina was applied to the surface. The surface should remain untarnished indefinitely.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Through this study, the selected alloys have been explored in their properties, and experimentated with in their application to the jewelry media. To summarize the findings determined through these various experimentations, the alloys will be discussed separately.

Both the commercial alloy of Britannia metal and the experimental alloy were of the same formula, 91% Sn, 7.5% Sb, and 1.5% Cu. It has been found that Britannia metal may be successfully cast in either the lost wax gravity cast method,* or the carved-out steam cast method.** Because of the alloys extremely low melting point and slow solidification rate, Britannia metal may not be centrifugally cast successfully. The experimental and commercial alloys readily received oxidation through the application of "pickle" solution. The alloys, when polished were a soft-looking silver-white on the raised surfaces. This surface will develop a patina, naturally, within five or six months, if it is not re-polished.

The commercial alloy of tin bronze employed in this study contains the following percentages of 88% Cu and 12% Sn. The experimental alloy contains 60% Cu and 40% Sn. Both the commercial alloy, which is a brass-yellow color, and the experimental alloy, a white-red, will receive an applied chemical patina on their surfaces through the use of the sulphurated potash solution. In the instances of the experimental alloy of tin bronze, the surface was polished completely free of all oxidation in order

* Figure 3

** Figure 5

to allow the metal to adapt a natural patina. It was found that the experimental alloy was quite brittle and crystalline in structure. When heated, the alloy can be fused to other metals, as was the case in this instance. The alloyed piece was fused to the silver necklace. No solder was necessary.

The percentages of metals utilized in both the commercial and the experimental alloys of aluminum bronze are the same, 95% Cu and 5% Al. The coloring of the two alloys are a light yellow. It has been found that in most instances, aluminum bronze will keep a high luster, indefinitely, after a polish, unless a patina is chemically applied. The two chemical solutions employed in this study on the aluminum bronze are sulphurated potash, and ammonium chloride. The former turns the metal a brown-black. The latter solution turns the metal a light green.

Duronze II, a commercial alloy of silicon bronze, was the alloy used in the exploration of the silicon bronze properties. The percentages of metals in this alloy are 97% Cu and 3% Si. The color of this alloy is a pink-yellow. A high luster can be applied to the alloy for an indefinite period of time. The alloy is highly resistant to chemicals, and it is difficult to apply to patina to the surface. Heat, applied by a torch, will oxidize the surface to a brown.

Both the commercial alloy and the experimental alloy of silver, which were used in this study, had the same formulas of 95% Ag and 5% Cu. The color of these alloys are white. A solution of sulphurated potash was applied to the surfaces of the silver alloys. The developing patina was blue-black in color. The recessed areas were left dark and the raised surfaces were polished to a high luster. In one of the jewelry pieces created in this study, silver was used in combination with tin bronze in

a bi-metal construction.* It was found in this exploration that tin bronze, which has a higher melting point than the silver alloy, can be successfully bi-metal cast with silver, even if it is the second metal to be cast.

This study had as its purpose (1) to apply metals which are adaptive to the casting of jewelry pieces; (2) to use a variety of methods in casting these pieces; and (3) to modify the designs in accordance with the alloy or alloys employed and the methods and materials used.

The purpose of this study has been realized. The selected alloys were verified in their ability to be adaptable to the casting of jewelry pieces exhibit what can be accomplished with the employment of alloys, normally ignored as valid jewelry media. Designs may have to be modified in accordance with the alloy or alloys employed and the materials and methods utilized, but results can be successful.

Three methods were utilized in this study to cast the selected alloys. Methods, such as these, may be applicable both in the public school and college classrooms.

Positive results were achieved in all the alloy explorations of this study ends. The incorporation of bi-metal construction with the selection of alloys in this study, and/or other alloys may be one area worthy of experimentation and discovery, in accordance with an adaptation to the jewelry media and/or small sculpture areas.

*Appendix

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APPENDIX

APPENDIX

Bi-metal Casting

This process involves two alloys which are preferably of different colors. A design is first cast in one alloy, the one with the higher melting point, and secondly, the piece is re-designed to incorporate a second alloy of a different color. The re-designing is worked out in wax in direct combination with the first alloy. This process can be extended to include three alloys.

Britannia Metal Alloying Process

In order to create the alloy of Britannia metal, the metals of copper, tin, and antimony must be combined in the following percentages of 91% Sn, 7.5% Sb, and 1.5% Cu. The metals are melted in a crucible and combined in a specific order, beginning with the copper which is of the highest melting point. As soon as the copper reaches the liquidous state, one-half of the tin is to be added. The alloyed metals must be stirred after each addition to insure a proper synthesis. The antimony is to be added next, and finally, the remainder of the tin is to be combined with the mixture. The resulting composite is Britannia metal.

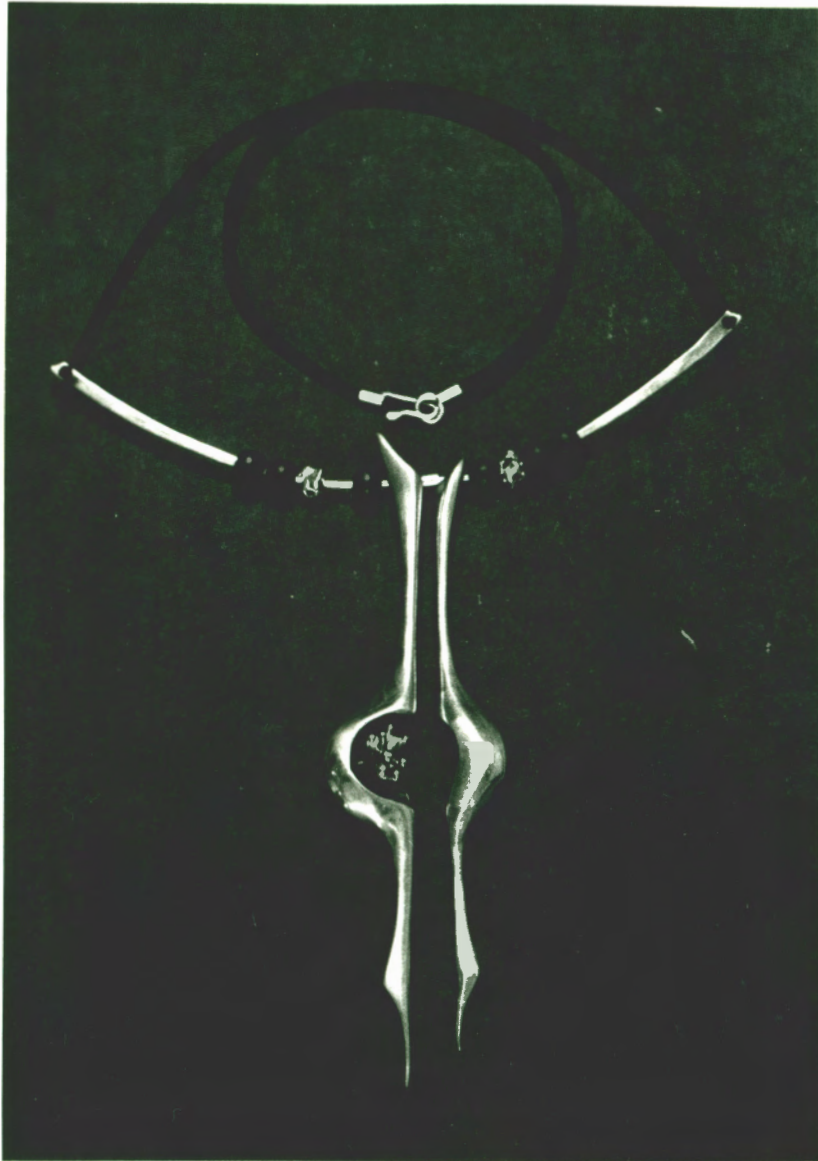


FIGURE 9

BRITANNIA METAL GRAVITY CAST PENDANT

Inspiration: Cherry Blossom Bud

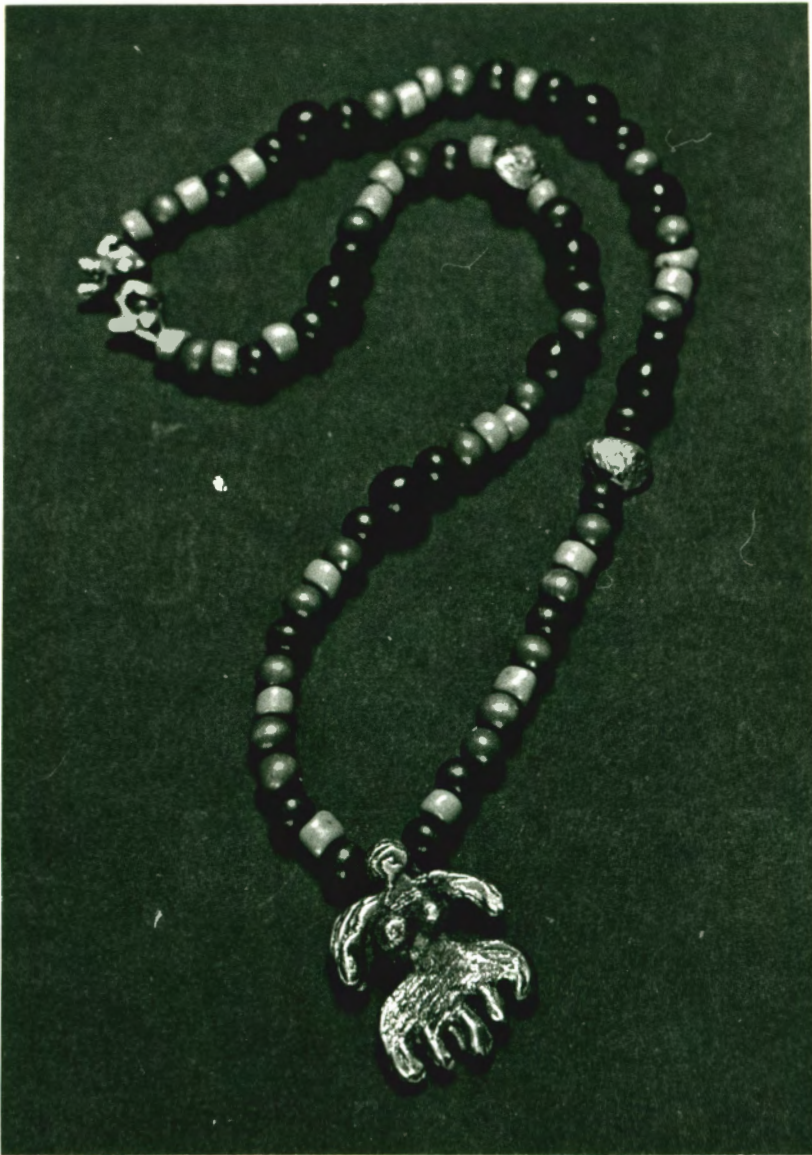


FIGURE 10

BRITANNIA METAL STEAM CAST PENDANT

Inspiration: Cuttlebone

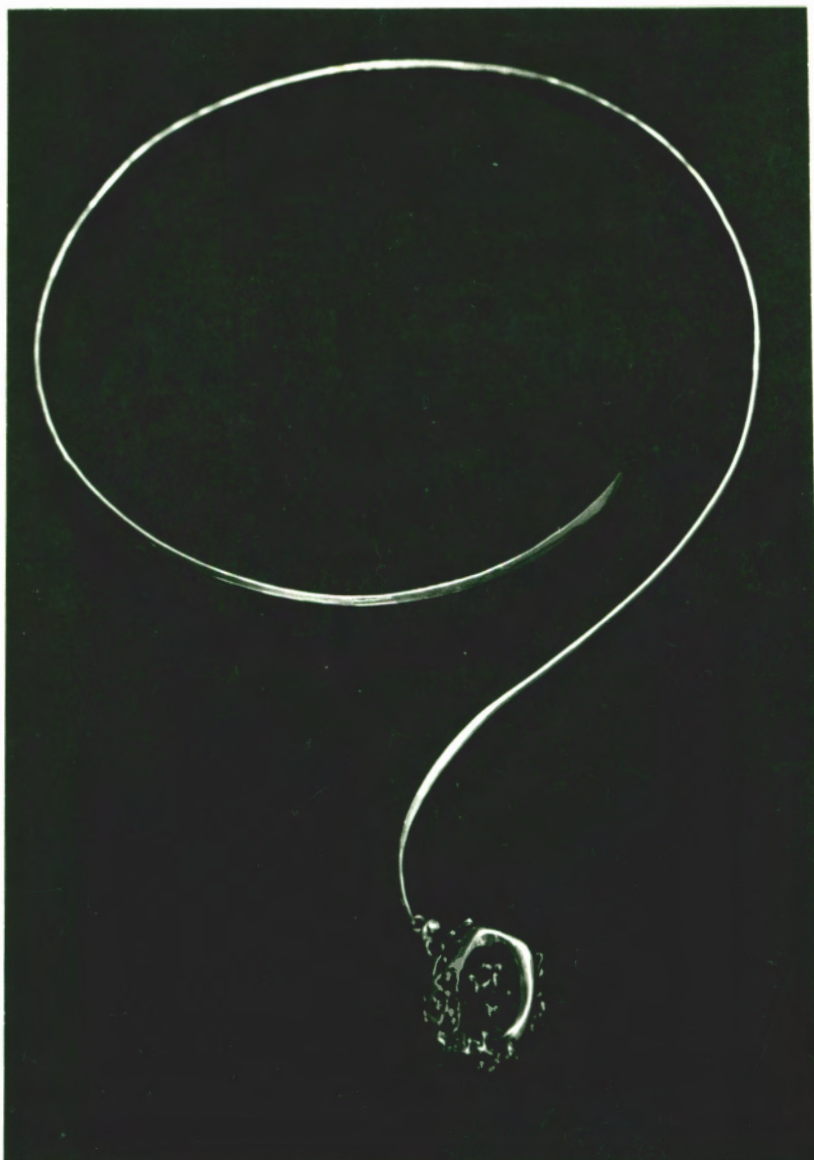


FIGURE 11

TIN BRONZE CENTRIFUGALLY CAST PENDANT

BI-METAL

Inspiration: People

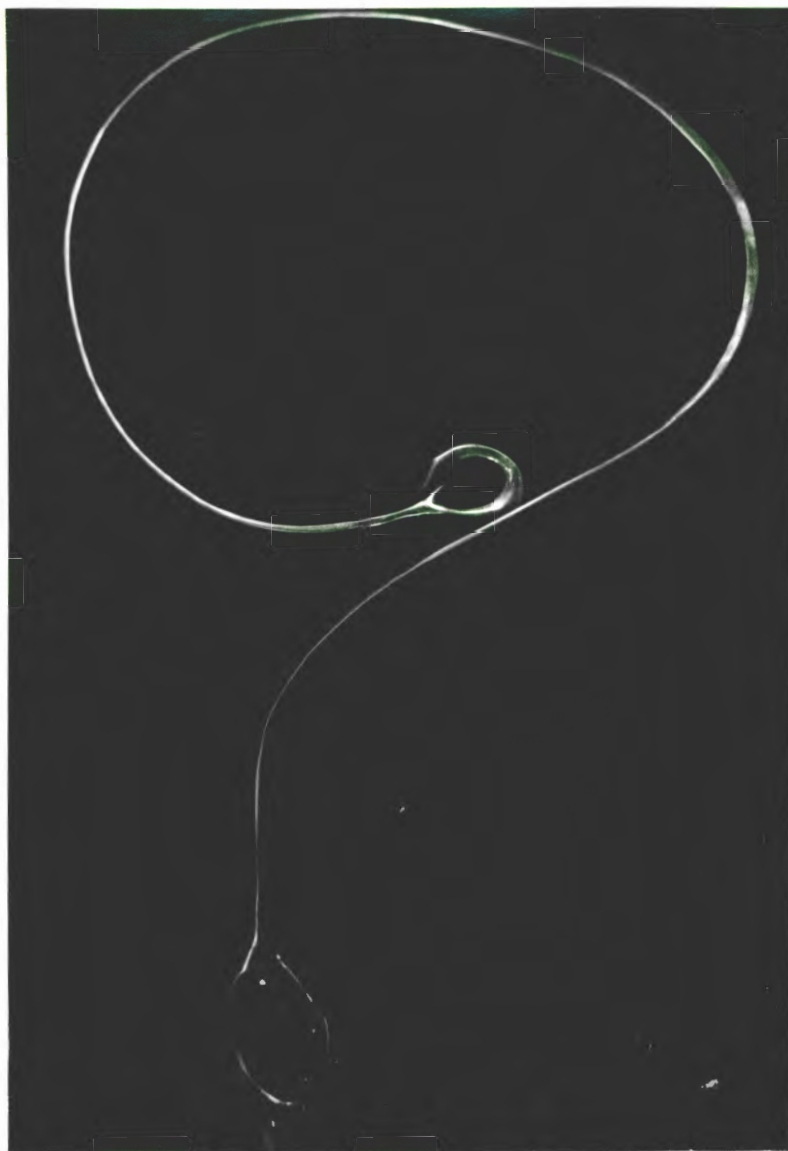


FIGURE 12

TIN BRONZE STEAM CAST PENDANT

Inspiration: Tree Leaf

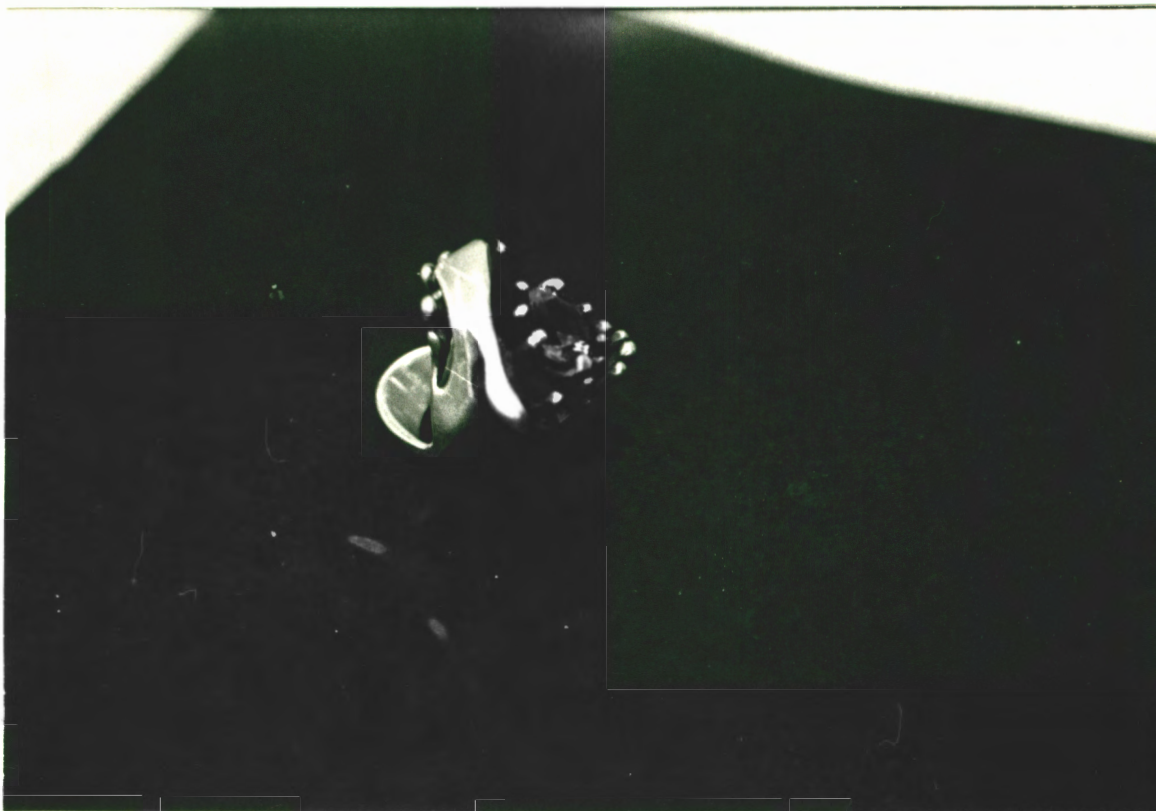
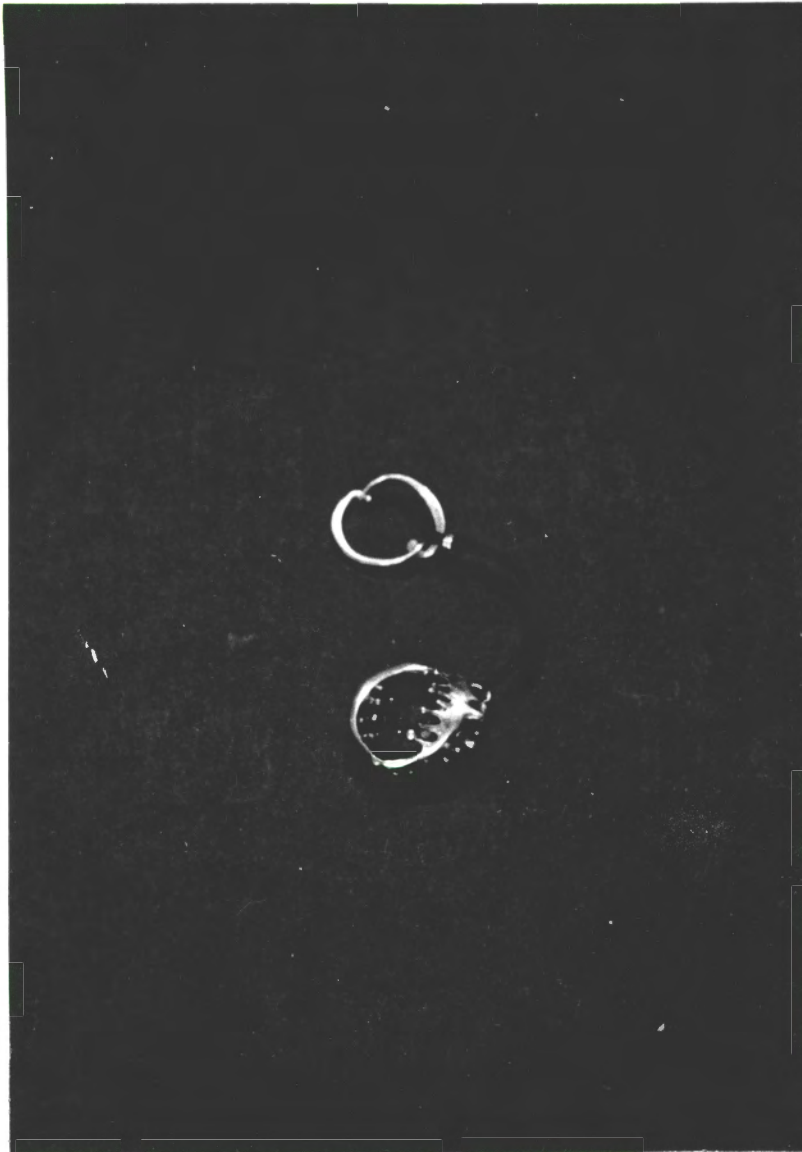


FIGURE 13
SILVER CENTRIFUGALLY CAST RING
Inspiration: The Stone



SILVER STEAM CAST KEY FOB

Inspiration: Rain Drop



FIGURE 15

ALUMINUM BRONZE CENTRIFUGALLY CAST PENDANT

Inspiration: Owl



ALUMINUM BRONZE STEAM CAST HAIR ORNAMENT

Inspiration: Tree Branches

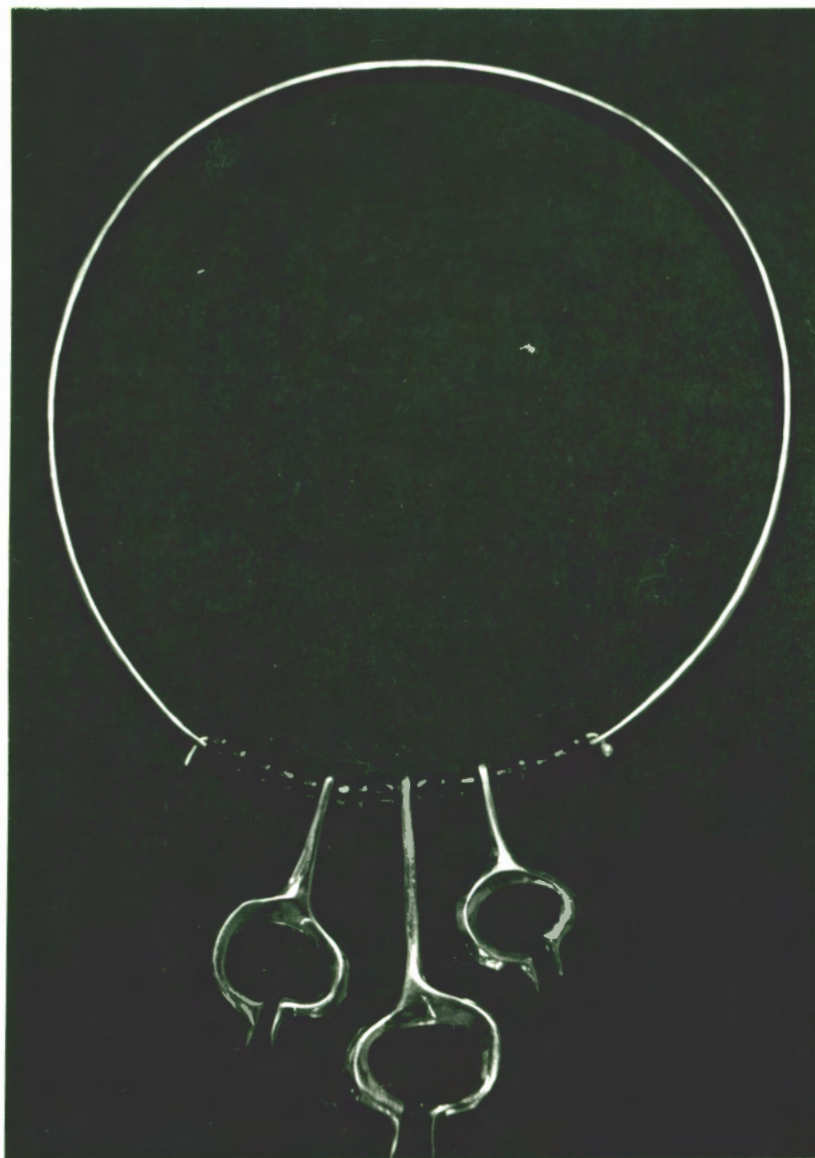


FIGURE 17

SILICON BRONZE CENTRIFUGALLY CAST PENDANTS

Inspiration: Plant Leaves



FIGURE 18

SILICON BRONZE CENTRIFUGALLY CAST KEY FOB

Inspiration: Couple In Love